National Aeronautics and Space Administration
Jet Propulsion Laboratory
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Old Spacecraft, New Mission: EPOXI's Approach to the comet Hartley-2

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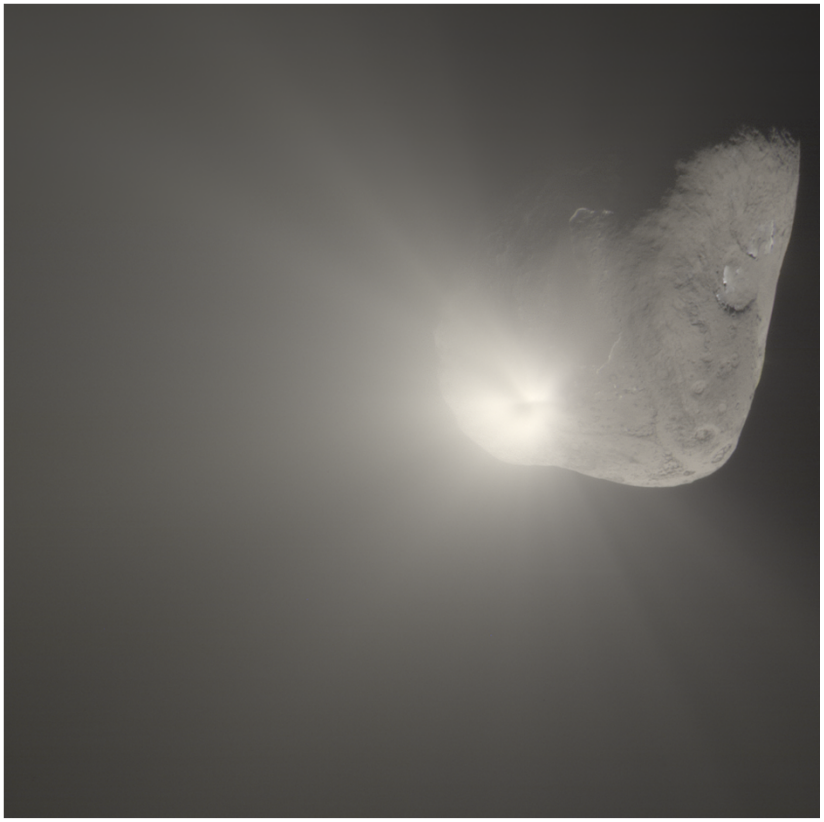
Overview

1. Deep Impact Prime Mission and EPOXI Mission of Opportunity
2. Encounter Organization
3. Constraints
4. Approach Phases
    1. Early-Approach
    2. Mid-Approach
    3. Late-Approach
5. Key Results
6. Conclusion

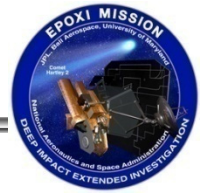
Deep Impact Prime Mission

- Launch: 12 January 2005
- Objective: Smash a mini-spacecraft into the comet Tempel-1 and observe
- Result:



Data courtesy of NASA, Image courtesy of Gordan Ugarkovic, www.unmannedspaceflight.com

EPOXI Mission of Opportunity



- EPOXI = EPOCh + DIXI
- EPOCh = **E**xtrasolar **P**lanetary **O**bservation and **Ch**aracterization
  - COMPLETE: Executed January 2008 – August 2008
- DIXI = **D**eep **I**mpact e**X**tended **I**nvestigation
  - COMPLETE: Flyby Comet Hartley-2 on 4 November 2010

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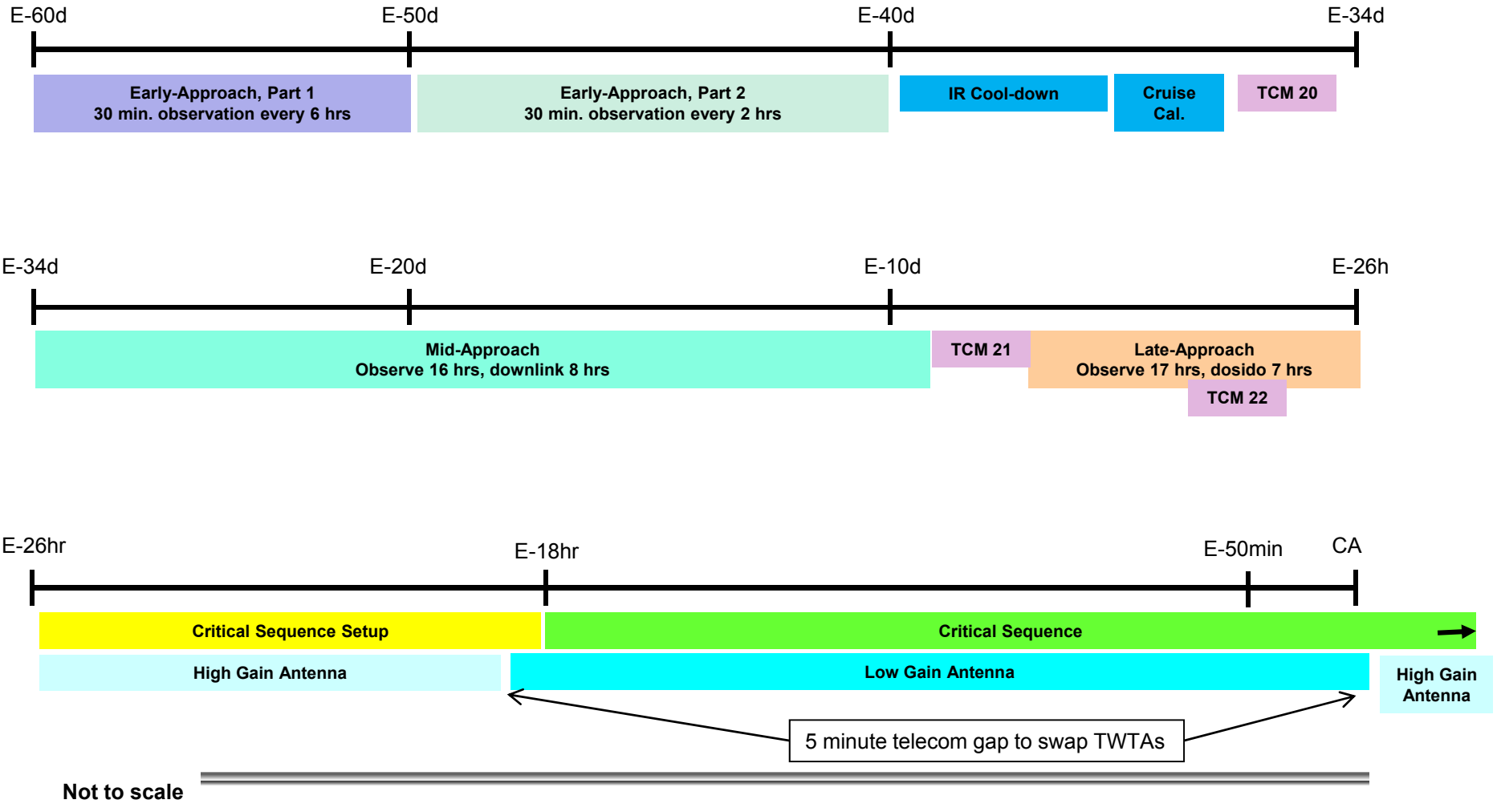
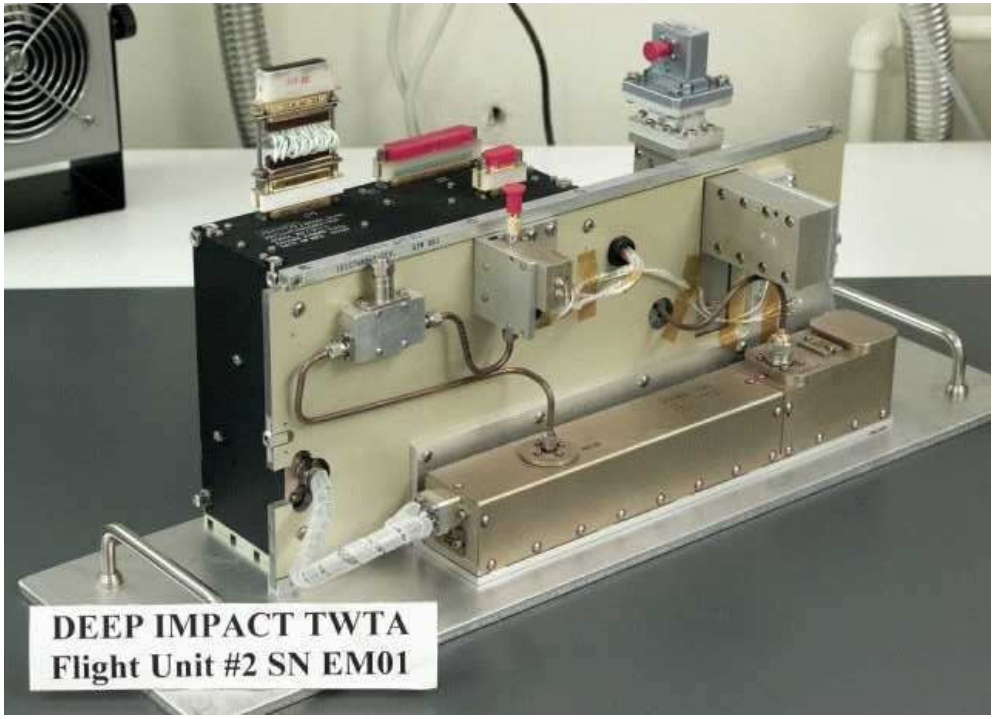
Approach & Encounter Overview



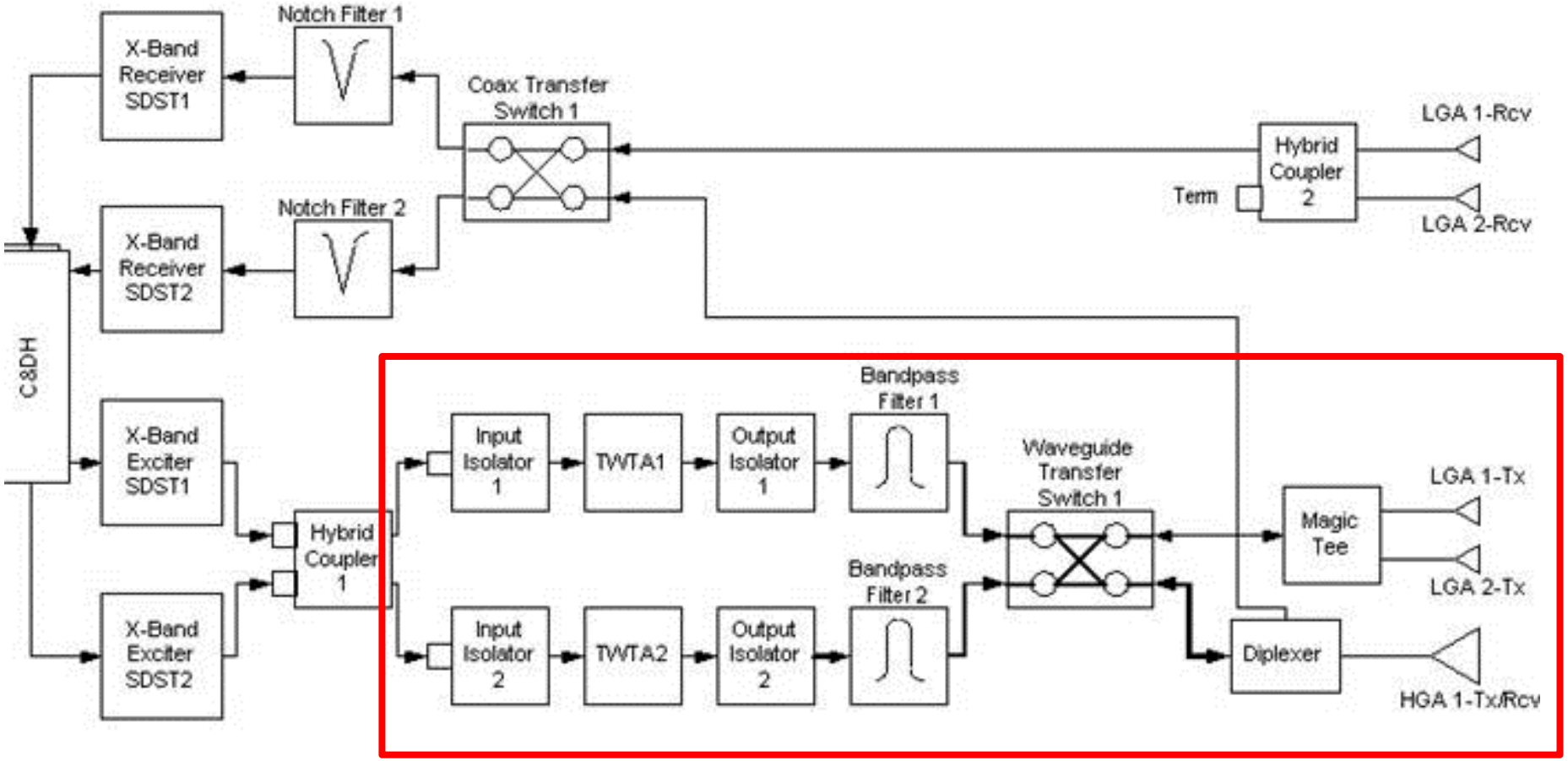
Not to scale

Constraints

- No flight software modifications
- Where's Boethin?
  - 2.5x the mission duration for the same budget
- Aging hardware
  - TWTA-A helix current
  - B-side RF power loss & risk to wave-guide transfer switch
- Result: No toggling the wave-guide transfer switch
  - Can only switch between HGA and LGA by swapping TWTAs



Telecom Subsystem



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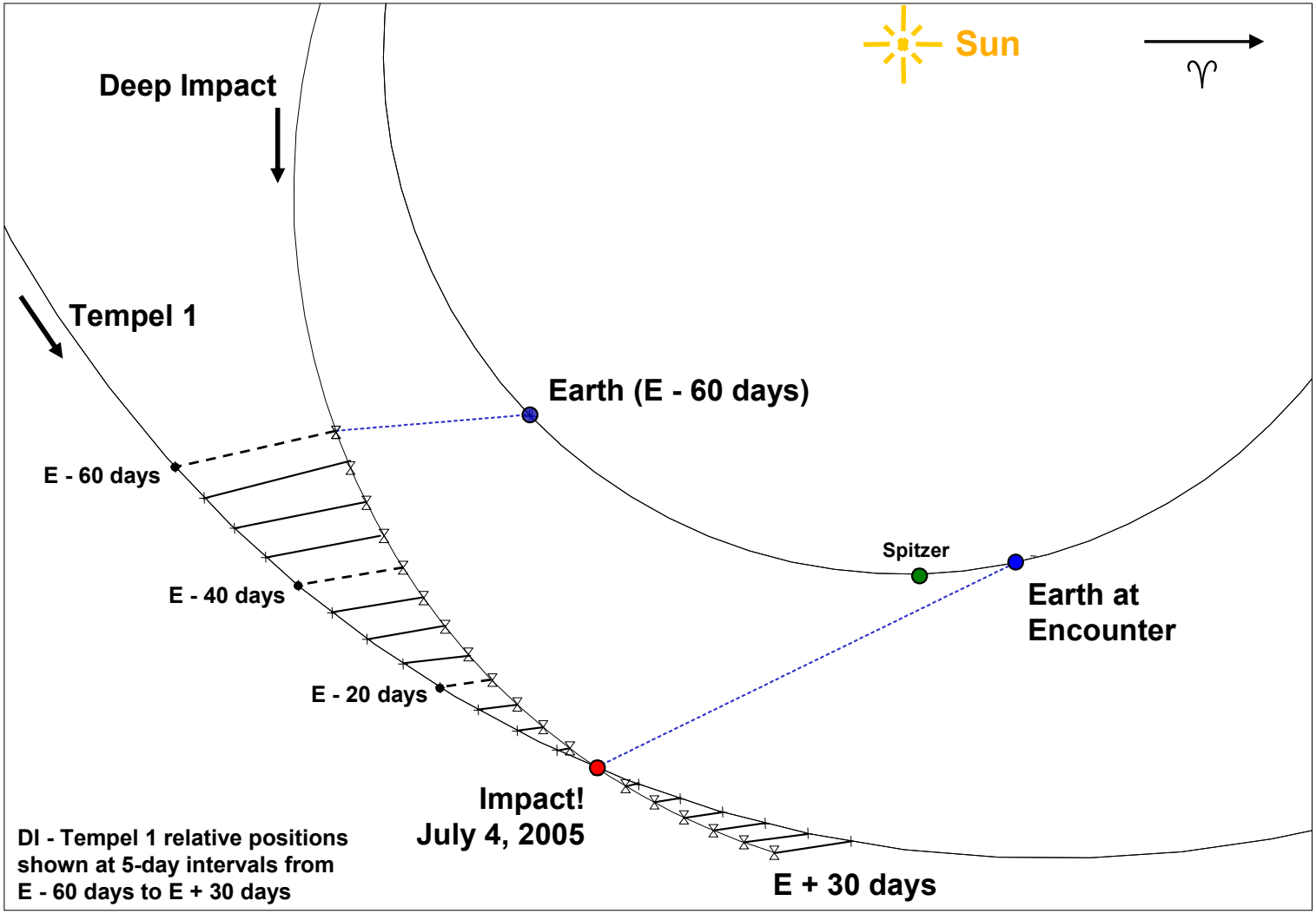
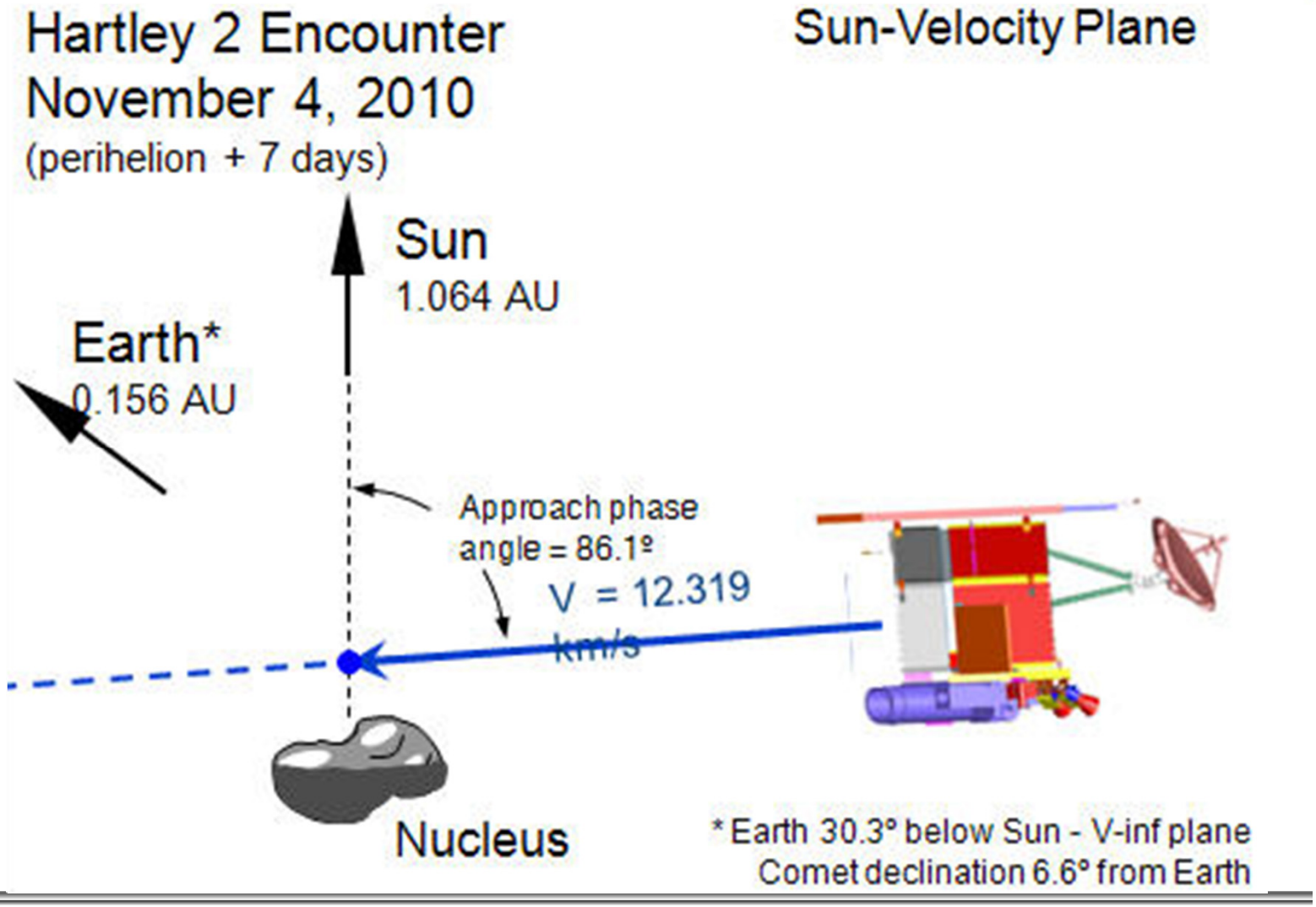
Deep Impact Orbital Geometry



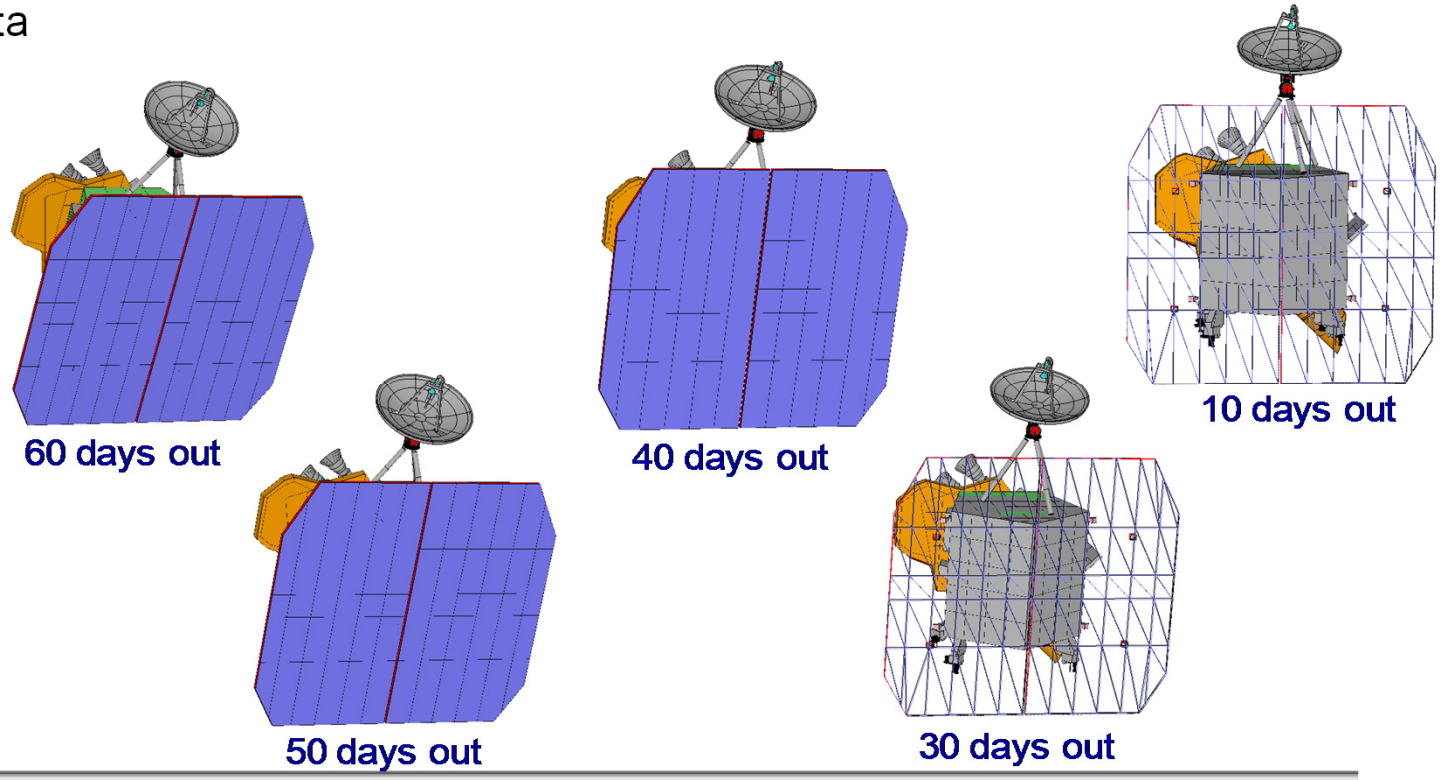
Deep Impact Flyby Spacecraft

EPOXI Geometry



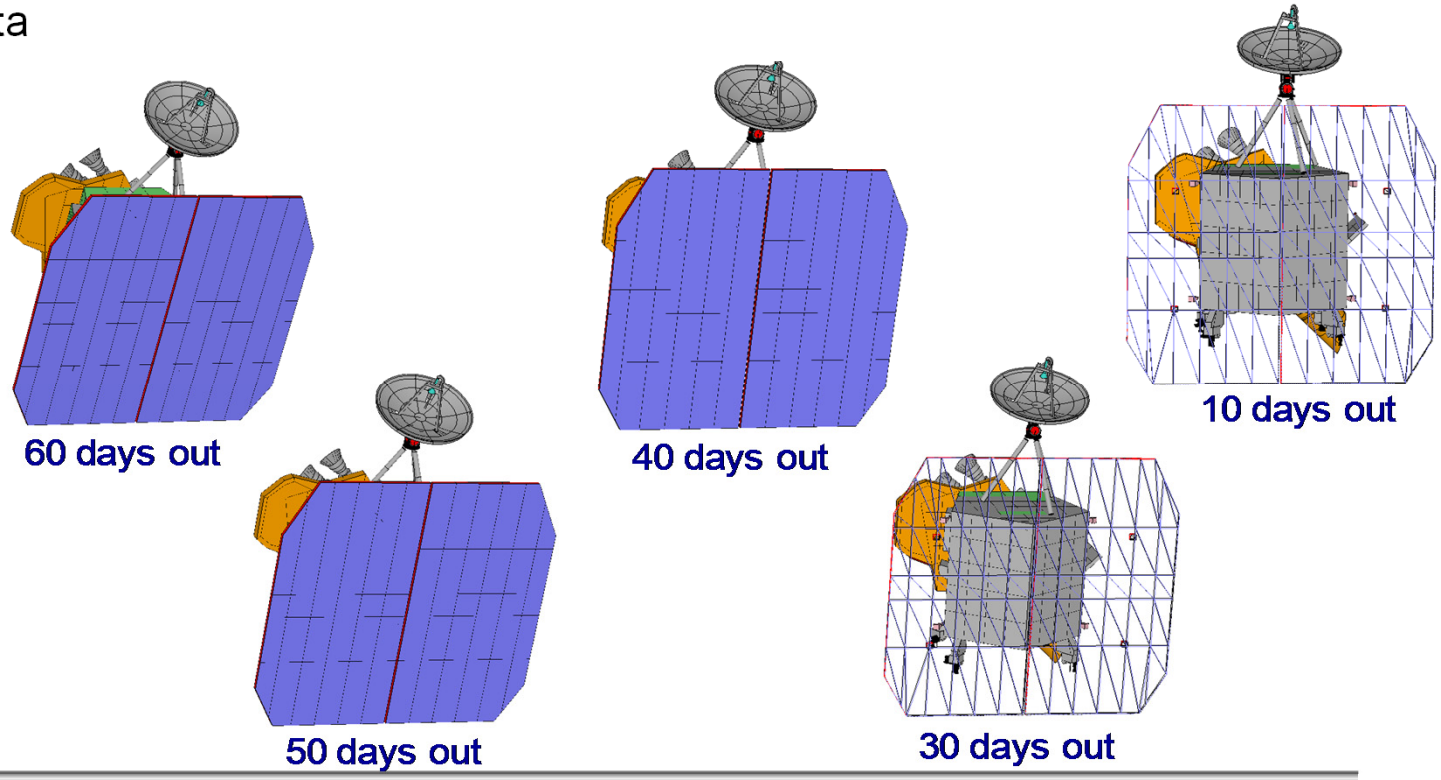
Early-Approach – Part 1
E-60d – E-50d

- Driven by thermal constraints
  - 6-hour cadence
  - 6.75-min slews
  - 30-min of imaging
  - No IR data

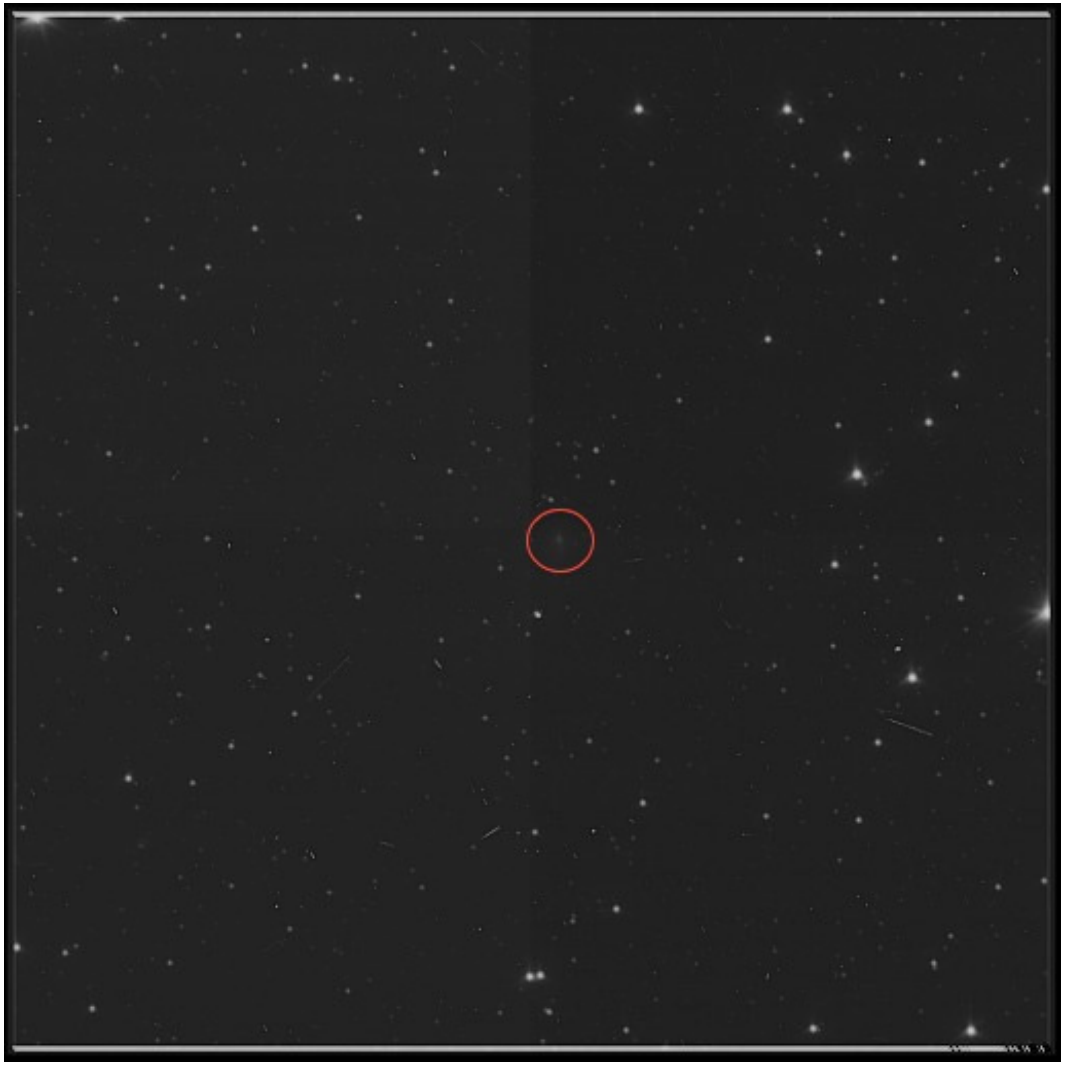


Early-Approach – Part 2
E-50d – E-40d

- Relaxed thermal environment
  - 2-hour cadence
  - 10-min slews
  - 30-min of imaging
  - No IR data



Early-Approach Results



First Interlude
E-40d – E-34d

- Cold soak to cool down IR detector — E-39d – E-36d
- Instrument Calibration — E-35d
- TCM-20 — E-34d

Mid-Approach
E-34d – E-8d

- Relaxed phase of approach
- 16-hours of imaging
- 30-min slews
- 7-hours at playback attitude
  - Only 5-hours needed for image downlink
- Able to conduct DDORs (advanced ranging)
- Time available for other engineering activities

Second Interlude
E-8d – E-8d

- TCM-21

Late-Approach

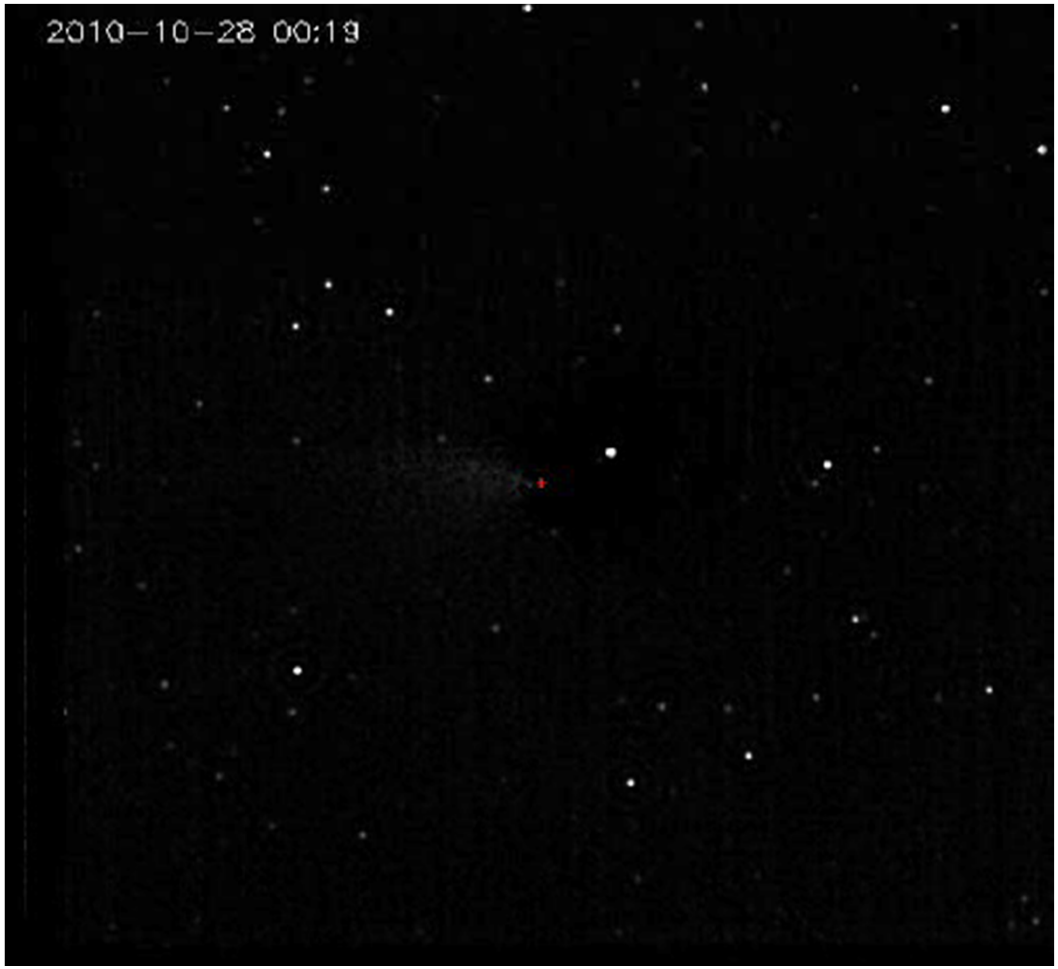
- 17-hours imaging
- 6.75-minute slews
- 7-hours toggling between comet & playback attitude
  - (Affectionately referred to as the “Do-Si-Do”)

1. Slew to playback attitude (6.75-min)
2. Downlink images (30-min)
3. Slew back to imaging attitude (6.75-min)
4. Image (16.5-min)
5. Repeat (x7)

- Challenges
  - DSN lockup every time at playback attitude
  - Only 77-seconds of margin on downlink time out of every 24-hours (0.09% margin)

Late-Approach

- TCM-22 at E-2d
  - Planned but not believed to be statistically necessary
  - Jets changed comet's orbit



Fast Facts

- 59-days of operations
- 27,382 unique MRI images
- 16,487 unique HRI images
- 20,030 unique IR spectra
- 63,899 total unique images or spectra

- Nucleus never spatially resolved during Approach

Conclusion

- Small, skilled team with lots of freedom and plenty of responsibility
- Unencumbered with bureaucracy
- Limited, but sufficient oversight

- EPOXI is an excellent example of spacecraft re-tasking
- Great scientific return on investment for NASA

- Never retire a spacecraft
  - If you can't figure out what to do, ask around for ways to keep operating

Questions?